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European Patent Office  
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(11) **EP 1 191 297 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
27.03.2002 Bulletin 2002/13

(51) Int Cl.7: **F28D 9/00**

(21) Application number: **01307730.0**

(22) Date of filing: **11.09.2001**

(84) Designated Contracting States:  
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE TR**  
Designated Extension States:  
**AL LT LV MK RO SI**

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(30) Priority: **23.09.2000 GB 0023427**

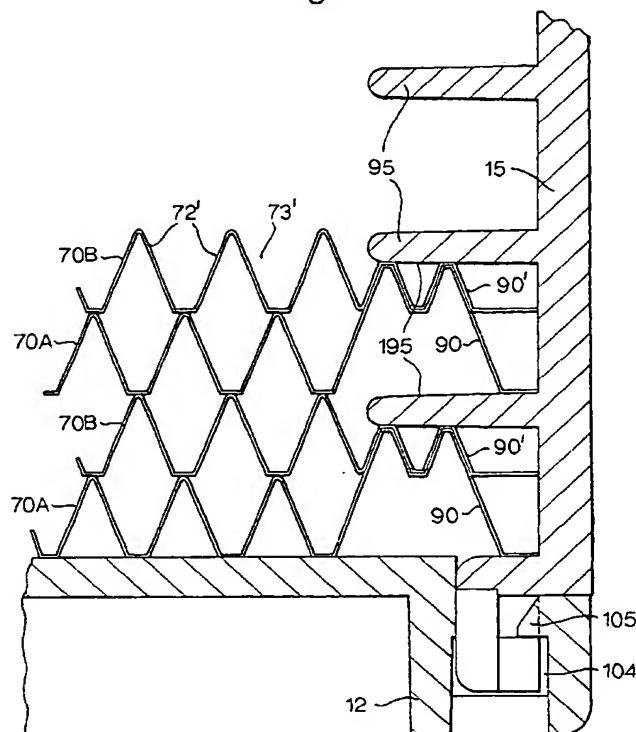
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(54) **Plate heat exchanger**

(57) A heat exchanger 6 has two inlets 63 and 64 and two outlets 65 and 66 for two counterflow air paths 7 and 8 through a stack plates 70. The plates 70 are vacuum-formed, each having a section 71 with zigzag walls 72 forming multiple flow channels 73 between adjacent plates. The edges of the plates have walls 90, 90'

that nest with one another and are retained and sealed between ribs 95 on two side plates 14 and 15. Four grilles 16 to 19 at the inlets and outlets have bars 97 with recesses 99 retaining the edges of pairs of plates 70, the bars being separated by spaces 98 allowing air to flow between adjacent pairs of plates and into or out of the air paths 7 and 8.

Fig.11.



## D scription

[0001] This invention relates to heat exchangers of the kind including a plurality of plates stacked above one another to define two separate fluid flow paths between alternate pairs of adjacent plates, and retainers for retaining the plates with one another.

[0002] The invention is more particularly concerned with heat exchangers for use in building ventilation systems.

[0003] Heat exchangers are used in building ventilation systems to transfer heat from warm air extracted from the building to cold air supplied to the building. In this way, the amount of energy needed to maintain the temperature within the building can be minimized.

[0004] A common form of heat exchanger used in building ventilation systems comprises a stack of thin parallel plates spaced from one another to form two separate flow paths between alternate pairs of plates. The warm air is supplied along one path and a part of its heat is conducted through the thickness of the plates to the cold air supplied along the other path.

[0005] The ideal heat exchanger should have a high efficiency of thermal transfer, preferably above about 90% and should produce only a low back pressure so as to reduce energy expenditure by the fans used to pass the air through the exchanger. The exchanger should also have a low leakage between the two air paths and be easy to manufacture at low cost.

[0006] The plates used in heat exchangers usually have low projecting walls to support the plates spaced from one another and to enhance performance. In one arrangement, the plates are moulded with zigzag paths on opposite sides, the plates being arranged with the paths out of phase with one another so as to ensure that the flow paths are kept open. Such an arrangement may have a high efficiency but produces a high back pressure because it results in considerable interruption to the air flow path as it passes between the intersecting walls on facing plates.

[0007] Conventional heat exchangers have the edges of their plates bonded with one another such as by an adhesive, solvent or by ultrasonic welding. These processes can produce effective seals between the two flow paths but are relatively expensive and require specialised machinery.

[0008] It is an object of the present invention to provide an alternative heat exchanger.

[0009] According to one aspect of the present invention there is provided a heat exchanger of the above-specified kind, characterised in that the retainers include a plurality of first and second surfaces facing one another between which edges of respective pairs of plates are retained in sealing engagement with one another.

[0010] The first and second surfaces are preferably provided on projecting ribs between which edges of pairs of the plates extend. The retainers may include four grilles located at each of the inlets and outlets of

the heat exchanger. The grilles may be slidable along the plane of a face of the exchanger, retaining an edge of adjacent plates in sealing engagement and retaining a gap between retained pairs of plates opening into one of the fluid flow paths. The heat exchanger preferably has inlet and outlet faces on adjacent faces of the exchanger respective grilles on adjacent faces being slidable towards one another to form a seal between adjacent edges of the grilles. The plates preferably have a plurality of internal walls defining multiple flow channels therebetween along the plates. The internal walls and channels on one side of the plates preferably have corresponding channels and walls on their opposite side. The plates may have a spacer to retain separation between adjacent plates over their surface. The spacer may include a projection in a channel, an internal wall adjacent the projection being reduced so that air flow along the channels is not impeded by the projection. The plates may have six sides, four of the sides being closed and two of the sides being open, each plate preferably having a side wall along the four closed sides, the side walls of adjacent plates nesting with one another.

[0011] A heat exchanger assembly according to the present invention, will now be described, by way of example, with reference to the accompanying drawings, in which:

- Figure 1 is a schematic plan view of the assembly;
- Figure 2 is a perspective view of the heat exchanger unit;
- Figure 3 is a perspective view of a top or base plate of the unit;
- Figure 4 is a perspective view of a side plate of the unit;
- Figure 5 is a perspective view of an end grille;
- Figure 6 is a sectional side elevation of the grille of Figure 5 along the line VI-VI of Figure 5;
- Figure 7 is a perspective view of one type of heat exchanger plate;
- Figure 8 is a perspective view of another type of heat exchanger plate;
- Figure 9 is an enlarged plan view of a part of one of the heat exchanger plates;
- Figure 10 is a cross-sectional side elevation of the plate along the line X-X of Figure 9;
- Figure 11 is a cross-sectional side elevation view of a lower, side part of the heat exchanger unit showing how the exchanger plates are

retained by the side plates; and

Figure 12 is a cross-sectional side elevation view of an upper, end part of the heat exchanger unit showing how the exchanger plates are engaged by the grilles.

[0012] With reference first to Figures 1 and 2, the heat exchanger assembly has an outer housing 1 with two inlets 2 and 3 and two outlets 4 and 5 located at four corners of the housing. A heat exchange unit 6 is located in the housing 1 and defines two separate air flow paths 7 and 8 through the housing. The first flow path 7 extends from the inlet 2 through the exchange unit 6 to the outlet 4 in the opposite corner and, in use, receives warm air exhausted from a room. The second flow path 8 extends from the other inlet 3 to the other outlet 3 and, in use, receives cold air from outside. The exchange unit 6 operates to transfer heat from the air flowing along the first flow path 7 to air flowing along the second flow path 8 so that the fresh air supplied to the building is warmed. The assembly includes two conventional electric fans 10 and 11 located in the housing 1 at the two outlets 4 and 5 to draw air along the respective flow paths 7 and 8.

[0013] The heat exchange unit 6 is of the counter-flow type having two parallel, vertical sides 61 and 62 and four end faces 63 to 66 providing the two inlets and outlets. The unit 6 has a horizontal base 67 and top 68. Operation of the two fans 10 and 11 causes warm air drawn in through the inlet 2 of the housing to flow in the inlet face 63, through the unit 6 and out of the diagonally opposite outlet face 65, from where it flows to the outlet 4. Cold air drawn in through the inlet 3 passes in the inlet face 64, through the unit 6 and out of the diagonally opposite outlet face 66, from where it passes to the outlet 5.

[0014] With reference now also to Figures 3 to 12, the heat exchange unit 6 comprises a parallel stack of forty-four, six-sided heat exchanger plates 70. The plates 70 are contained within a base plate 12, a top plate 13, two side plates 14 and 15 and four inlet grilles 16 to 19. Each plate 70 is formed with walls at its edges to provide a seal around four of its six sides, leaving two diagonally-opposite sides open for inlet and outlet of air. The heat exchanger plates 70 are vacuum formed from a thin sheet of carbon-loaded uPVC of a black colour, which has a high thermal conductivity and is an efficient thermal radiator. The plates 70 are moulded with a pattern of internal walls to form channels therebetween on opposite surfaces that act to contain air flowing through the exchanger along defined paths through the exchange unit 6. The heat exchanger plates 70 are of two different types: a lower type A and an upper type B, which are stacked alternately one above the other. The configuration of the lower type of plate 70A will now be described with reference to Figure 7.

[0015] The plate 70A has a main section 71 of rectangular shape with forty-three internal walls 72 of zigzag shape extending parallel with one another longitudinally

of the plate and defining forty-two zigzag channels 73 extending along the plate between the walls. The walls 72 project vertically on the upper surface of the plate and are moulded from the material of the plates so as to form a corresponding pattern of channels and walls on the underside of the plate.

[0016] At opposite ends of the main section 71, the plate 70A has an inlet and outlet section 74 and 75, both of triangular shape. One side 76 of the inlet section 74 has a raised edge wall 77, to close the side, and the other side 78 is open with a slightly lowered edge 79. Where the raised wall 77 meets the open side 78 there is a small step 177 aligned longitudinally of the plate. The surface of the inlet section 74 is ribbed with shallow, parallel ribs 80 extending laterally of the plate and generally transversely to the direction of air flow. The inlet section 74 also has three higher raised walls 81 extending perpendicular to the open side 78. These ribs 80 and walls 81 act to channel air entering the open side 78 substantially evenly across the row of ends of the zigzag channels 73. The ribs 80 also introduce a small amount of turbulence into the air flow. The outlet section 75 similarly has a closed side 82 with a raised wall 83, and an open side 84 which connects with the closed side via a step 183. The outlet section 75 also has ribs 85 and walls 86 to help channel air emerging from the zigzag channels 73 to the open side 84 of the section. A location pip 87 projects upwardly at opposite ends of the plate 70A, just within the apex of the inlet and outlet sections 74 and 75. The two sides of the main section 71 are each closed by a raised wall 90 having an M-shape profile (Figure 11) extending longitudinally along the plate.

[0017] The upper type of plate 70B (Figure 8) has similar surface formations, which are given the same number as the formations for plate 70A with the addition of a prime '. The inlet section 74' of the upper plate 70B is at the opposite end from that of the lower plate 70A. The plates 70B are stacked alternately above the plates 70A and have a pattern of zigzag channels 73' identical with the channels 73 except that they are displaced slightly laterally such that the walls 72' align with the channels 73. In this way, the channels defined by the underside of the walls 72' are aligned with the channels 73 on the upperside of the plates 70A to form channels between adjacent plates of diamond shape in section. The top of the internal walls 72 on the plates 70A support the base of the channels 73' on the plates 70B.

[0018] Along the two sides, the main section 71' of the plate 70B has side walls 90' of reduced height and of M-shape in section, which nest on the top of the side walls 90 of the lower plates 70A.

[0019] The triangular inlet and outlet sections 74' and 75' at the ends of the upper plates 70B are also similar to those of the lower plates 70A except that different ones of the sides 76', 78', 82' and 84' are open and closed and the internal ribs 80', 85' and walls 81', 86' act to channel air between the open sides 78', 84' and the ends of the zigzag channels 73'. The inlet and outlet sec-

tions 74' and 75' similarly have locating pips 87' the underside of which are engaged by the locating pips 87 on the lower plates 70A.

**[0020]** In order to ensure that the zigzag walls on adjacent plates do not nest with one another and thereby restrict flow, the pattern of zigzag walls is interrupted over the surface of the lower plate 70A by several raised pips 92 (Figures 9 and 10) located in channels 73 between the internal walls 72. The walls 72 in the region of these pips 92 is reduced in height to form notches 93 so that air flowing along the channels 73 can flow through the notches into adjacent channels and is not restricted by the presence of the pips.

**[0021]** The plates 70A and 70B are held together with one another in a stack by means of the bottom plate 12, top plate 13, side plates 14 and 15 and the grilles 16 to 19. The side plates 14 and 15 (shown most clearly in Figures 4 and 11) are imperforate and moulded of a rigid, black ABS plastics material with twenty-three parallel ribs 95 extending horizontally along their length. The spacing between adjacent ribs 95 and their height are such that each pair of ribs receives between them the mated side walls 90 and 90' of a pair of plates 70A and 70B, the facing surfaces 195 of adjacent ribs retaining and clamping the two walls together to form a secure seal.

**[0022]** The four grilles 16 to 19 (shown most clearly in Figures 5, 6 and 12) are each of similar construction, having twenty-three horizontal, parallel cross-bars 97 spaced apart from one another to form slots 98 through which air can enter between adjacent pairs of plates. The external surface of the cross-bars 97 is rounded to give an aerodynamic profile promoting free flow of air into the slots 98. Internally, each cross-bar 97 has a recess 99 with opposite facing surfaces 199 between which the edges of a pair of plates 70A and 70B are received and retained together in sealing engagement. The grilles 16 to 19 are assembled on the unit 6 by aligning one end of the recesses 99 with the corners of the exchanger plates 70A and 70B where they are supported by the side plates 14 and 15 so that the edges of a pair of plates locates in respective recesses. The grilles 16 to 19 are then slid along their length, parallel to the edge of the plates 70A and 70B, towards the apex. Where two grilles 16 and 19, 17 and 18 meet at the apex, they clamp onto the steps 177 and 183 on the plates 70A and 70B to ensure a good sealing fit along the end of the unit 6. Each grille 16 to 19 has an L-shape ledge 100 along the vertical edge, which locates at the apex. Each grille 16 to 19 also has an angled ledge 101 along its opposite edge, which overlaps the edge of the adjacent side plate 14, 15. Along the top and bottom vertical edge of each grille 16 to 19 extends a channel 102 with clips 103, which fasten onto the edges of the top and bottom plates 13 and 12. Similarly, the top and bottom plates 13 and 12 both have channels 104 along their sides with clips 105 (Figure 11), which fasten onto the top and bottom edges of the side plates 14 and 15.

**[0023]** Considering the grilles 16 and 19 at one end of the unit 6, one of these grilles 16 seals together the edge 84 of each lower plate 70A to the edge 84' of the upper plate 70B directly below it. The slots 98 in the grille 16, therefore, open into spaces between the upper surface of the lower plates 70A and the lower surfaces of the upper plates so that the air flow path 7 extends between these surfaces. The adjacent grille 19, however, seals together the edge 83 of each lower plate 70A to the edge 83' of the upper plate 70B directly above it so that the slots 98 in the grille open into the air flow path 8 extending between the upper surface of the upper plates and the lower surface of the lower plates. The warm air flowing along flow path 7 flows along the channels 73, 73' in a direction that is parallel to but opposite from the cold air flowing along the flow path 8. Heat in the exhaust air flow path 7 is conducted through the thickness of the plates 70A and 70B into the inlet air flow path 8. The construction and arrangement of the plates 70A and 70B ensure that the heat only has to flow through a single layer of material between adjacent flow paths.

**[0024]** The unit 6 is assembled by clipping the side plates 14 and 15 into the base plate 12 and then sliding a pair of heat exchange plates 70A and 70B into the gaps between the ribs 95 along the side plates, with the plates being located together by engagement of the pip 87 in the lower plate in the corresponding location point 87' in the upper plate. When all the pairs of plates 70 have been slid into position, the top plate 13 is clipped onto the upper edge of the side plates 14 and 15. The grilles 16 to 19 are then slid into place in the manner previously described. In this way, the entire unit 6 can be assembled without the use of adhesives, solvents and without having to weld or bond components together.

**[0025]** The heat exchanger unit 6 has six vertical edge projections 111 to 116 located around its surface and provided on the grilles 16 to 19 and side plates 14 and 15. These projections are a close sliding fit in channels 211 to 216 formed on the inside surface of the housing 1, which is of a foamed plastics material, so that the unit 6 can be slid down into the housing. The engagement of the projections 111 to 116 in the channels 211 to 216 forms a seal preventing passage of air between the outside of the exchange unit 6 and the inside of the housing 1.

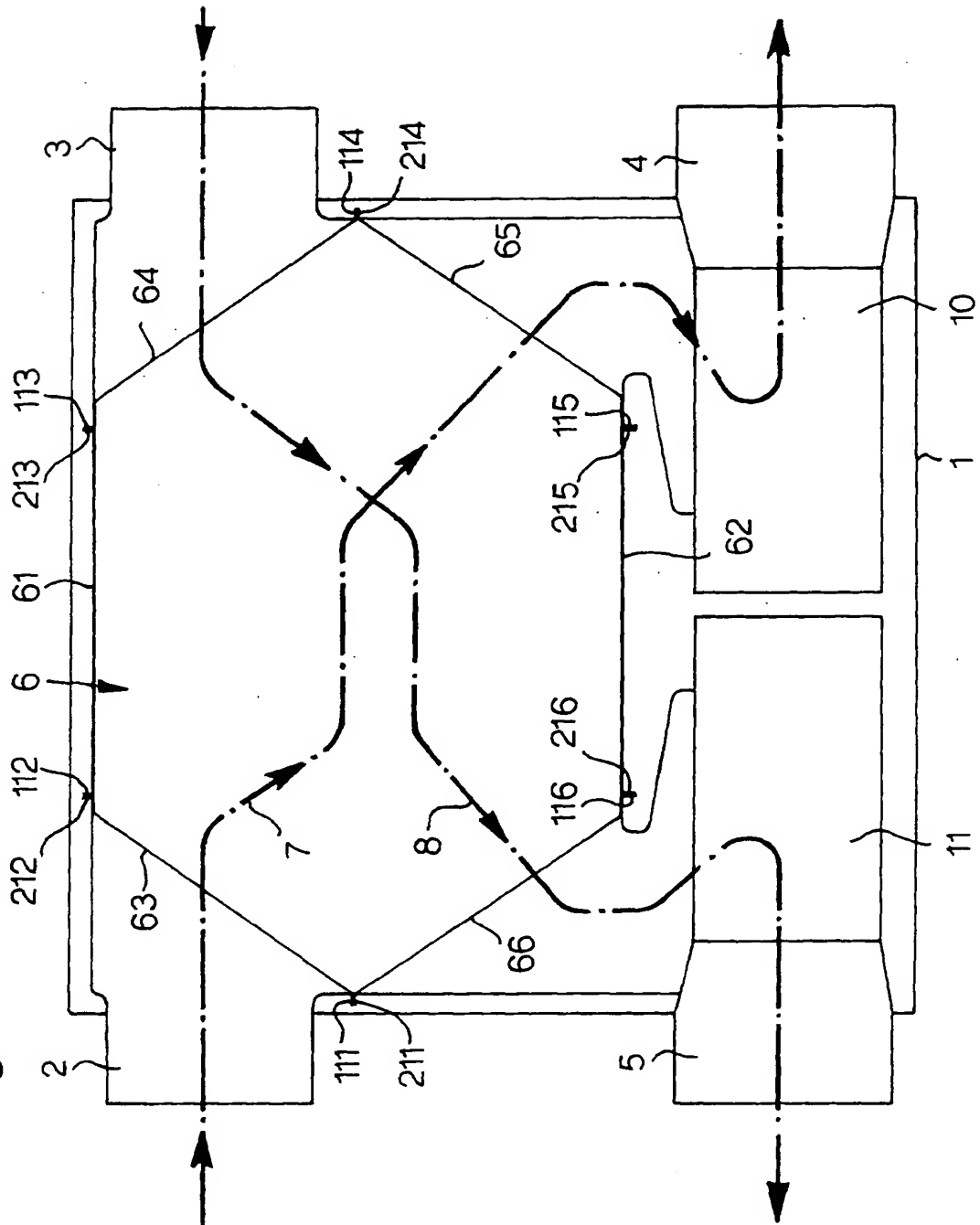
**[0026]** The arrangement of the present invention has several advantages. The manner in which the plates are retained together at their edges avoids the need for any adhesive or welding, thereby considerably simplifying assembly and reducing costs. The aligned, zigzag air flow paths on the upper surface of one plate and the lower surface of an adjacent plate enables a relatively low back-pressure to be achieved, whilst the spacer pips ensure that the air flow paths remain open. Previous exchange plates with zigzag paths have been arranged out of phase with one another so that the walls on adja-

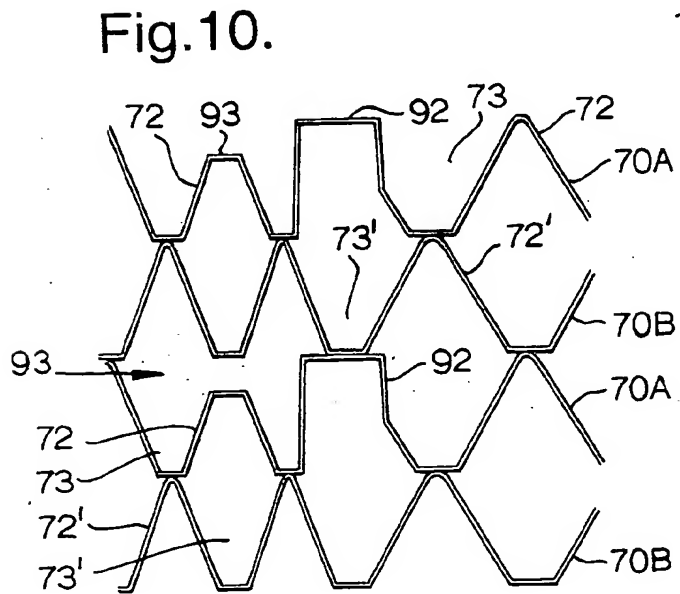
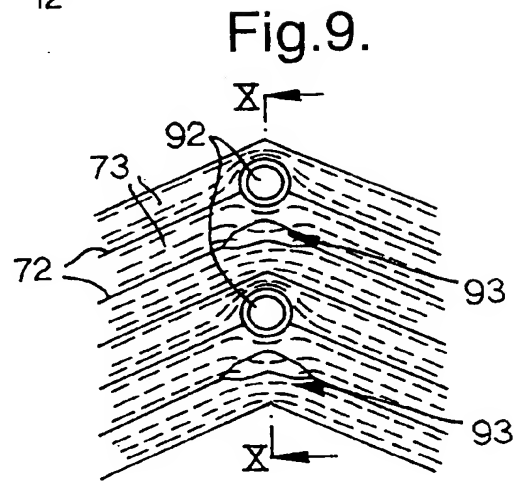
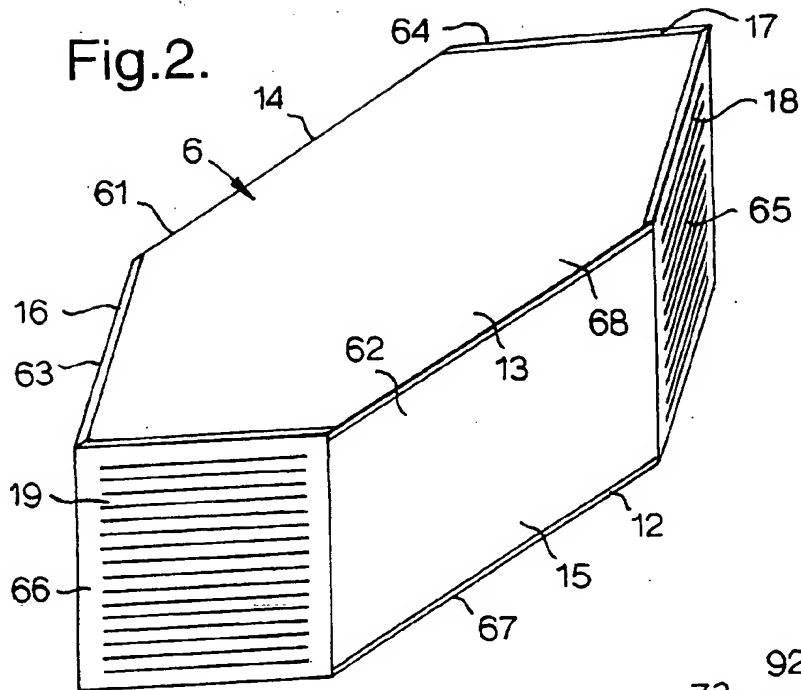
cent plates cross and support one another. This previous arrangement produces considerable air flow disturbance and results in relatively high back-pressure compared with the arrangement of the present invention. By sliding the grilles into position the alignment of the grilles with the individual plates is considerably simplified compared with alternative arrangements.

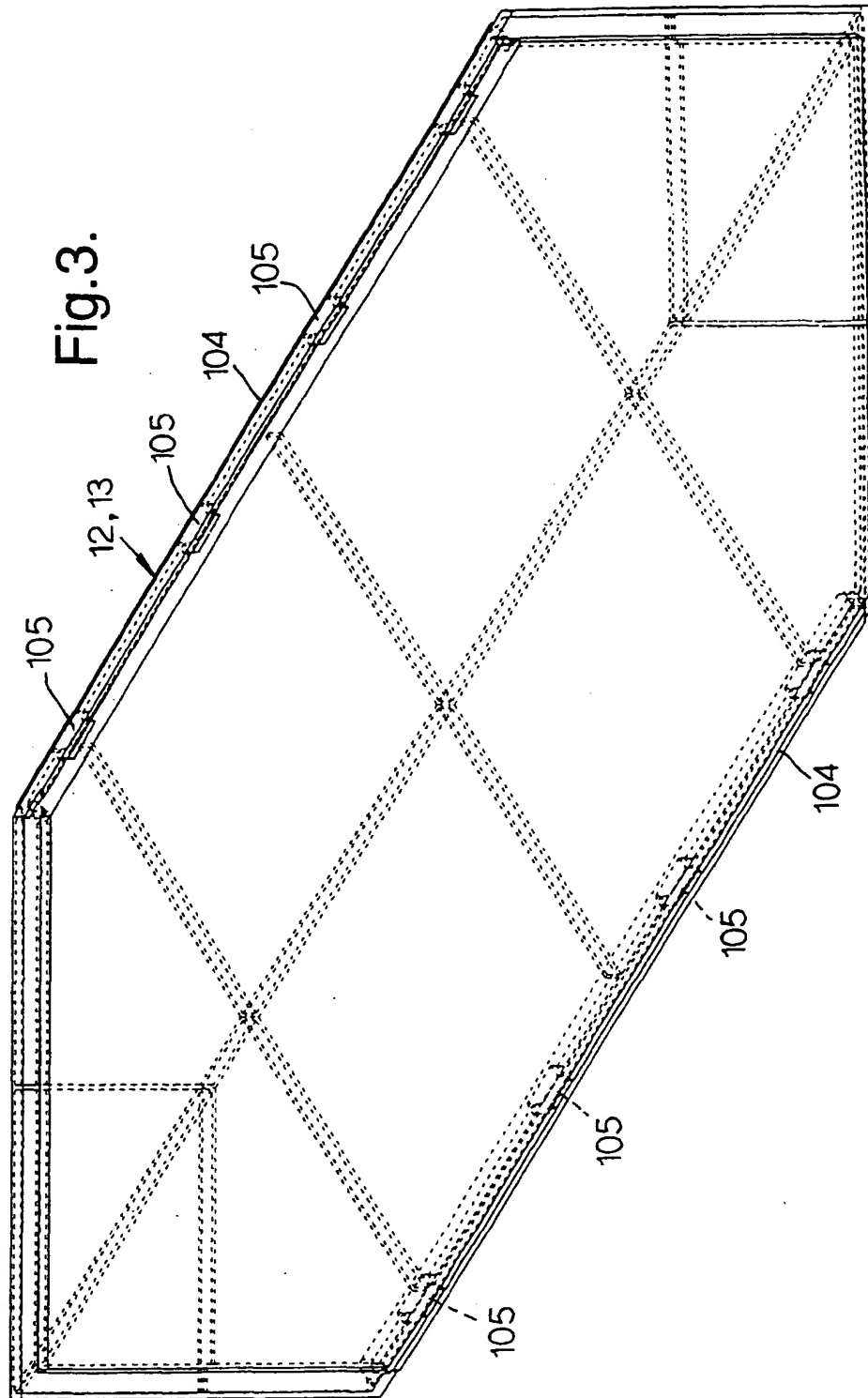
#### Claims

1. A heat exchanger including a plurality of plates (70) stacked parallel above one another to define two separate fluid flow paths (7 and 8) between alternate pairs of adjacent plates, and retainers (14 to 19) for retaining the plates with one another, **characterised in that** the retainers (14 to 19) include a plurality of first and second surfaces (95, 97) facing one another between which edges of respective pairs of plates are retained in sealing engagement with one another.
2. A heat exchanger according to Claim 1, **characterised in that** the first and second surfaces are provided on projecting ribs (95, 97) between which edges of pairs of the plates (70) extend.
3. A heat exchanger according to any one of the preceding claims, **characterised in that** the retainers include four grilles (16 to 19) located at each of the inlets and outlets (63 to 66) of the heat exchanger.
4. A heat exchanger according to Claim 3, **characterised in that** the grilles (16 to 19) are slidable along the plane of a face of the exchanger, that the grilles retain an edge of adjacent plates (70) in sealing engagement and retain a gap between retained pairs of plates opening into one of the fluid flow paths (7, 8).
5. A heat exchanger according to any one of the preceding claims, **characterised in that** the heat exchanger has inlet and outlet faces (63 and 66, 64 and 65) on adjacent faces of the exchanger, and that respective grilles (16 and 19, 17 and 18) on adjacent faces are slidable towards one another to form a seal between adjacent edges of the grilles.
6. A heat exchanger according to any one of the preceding claims, **characterised in that** the plates have a plurality of internal walls (72) defining multiple flow channels (73) therebetween along the plates.
7. A heat exchanger according to Claim 6, **characterised in that** the internal walls (72) and channels (73) on one side of the plates (70) have corresponding channels (73) and walls (70) on their opposite side.
8. A heat exchanger according to any one of the preceding claims, **characterised in that** the plates (70) have a spacer (92) to retain separation between adjacent plates over their surface.
9. A heat exchanger according to Claim 8 and Claim 6 or 7, **characterised in that** the spacer includes a projection (92) in a channel (73), and that an internal wall (72) adjacent the projection (92) is reduced so that air flow along the channels is not impeded by the projection.
10. A heat exchanger according to any one of the preceding claims, **characterised in that** the plates have six sides, that four of the sides are closed and two of the sides are open, that each plate has a side wall (90, 90', 83, 83', 77, 77') along the four closed sides, and that the side walls of adjacent plates nest with one another.

Fig.1.







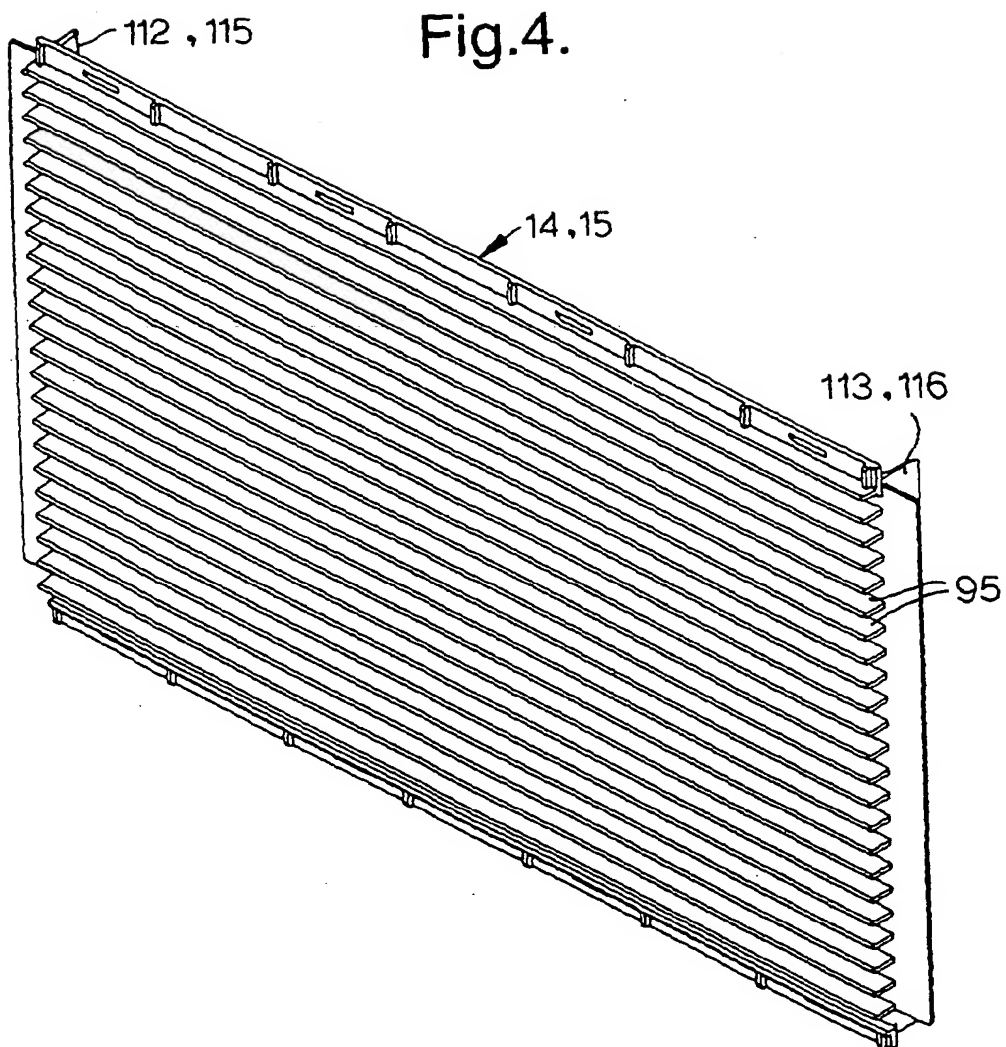


Fig.5.

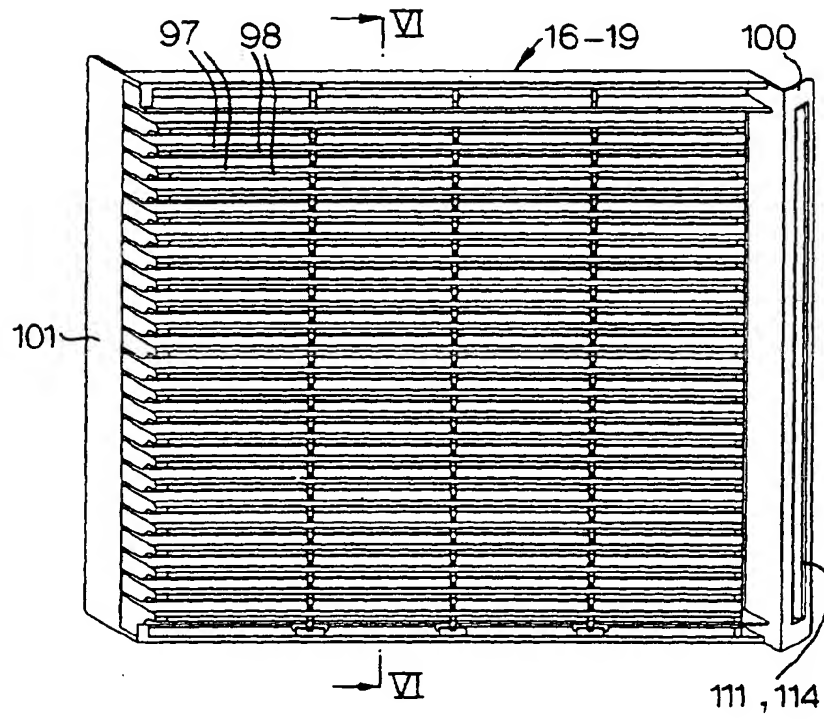


Fig.6.

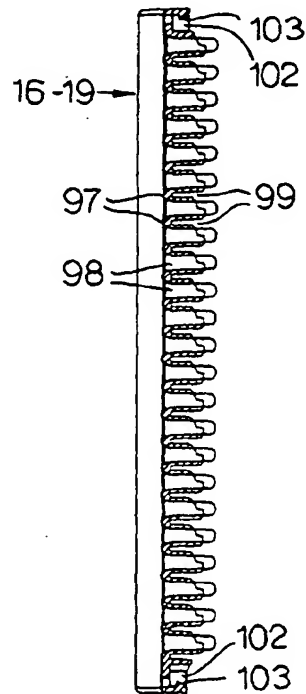


Fig.7.

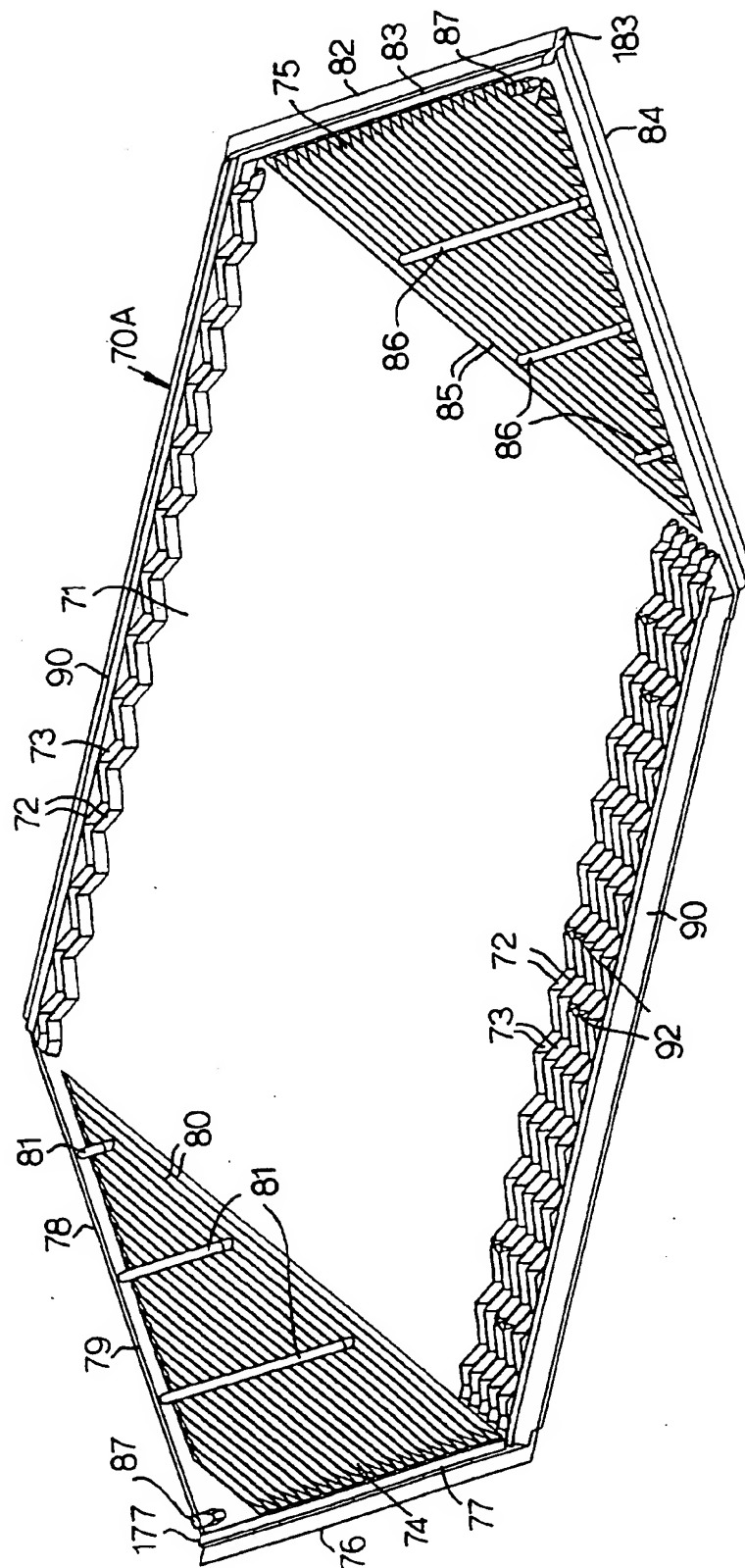


Fig.8.

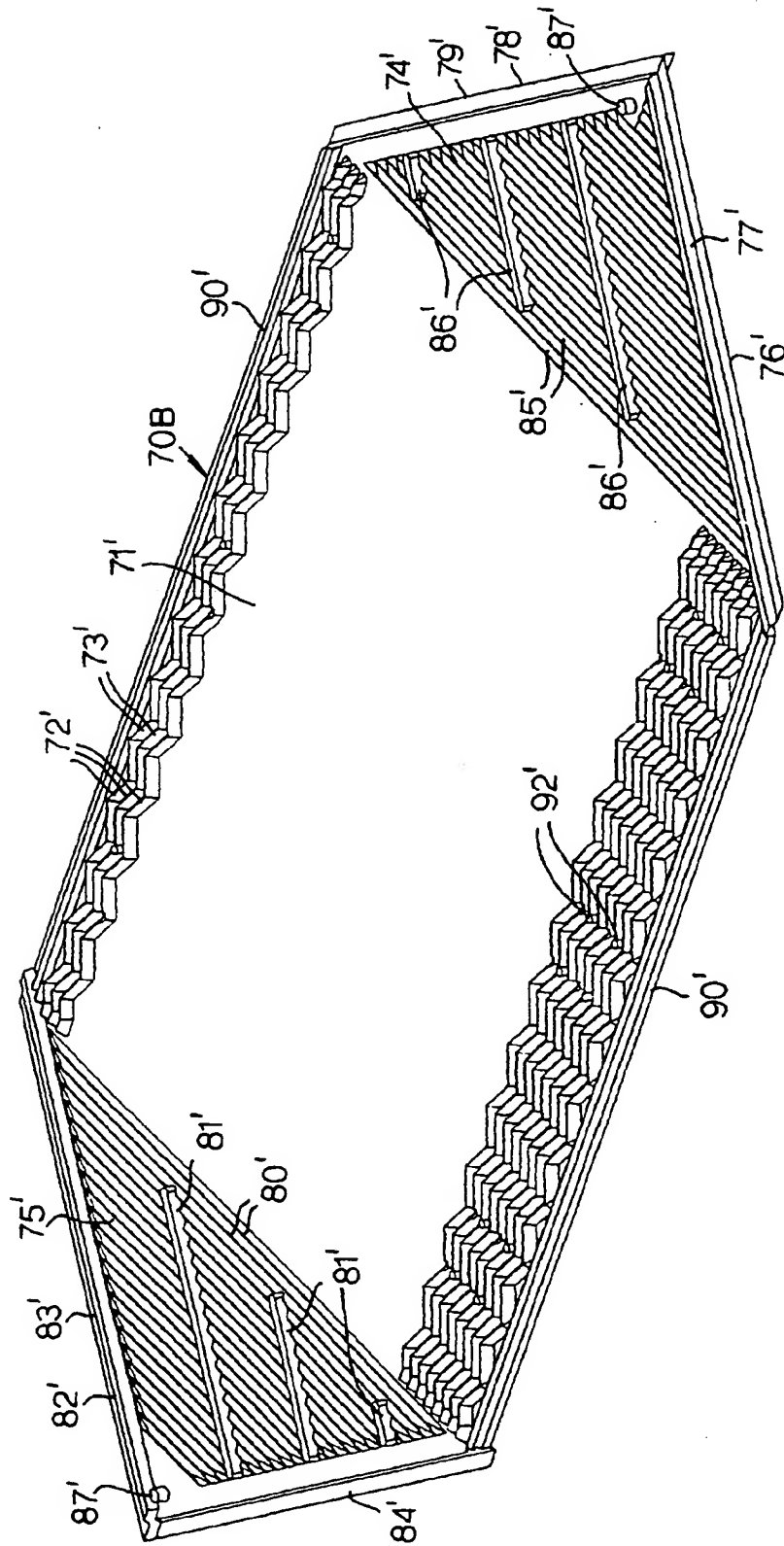


Fig.11.

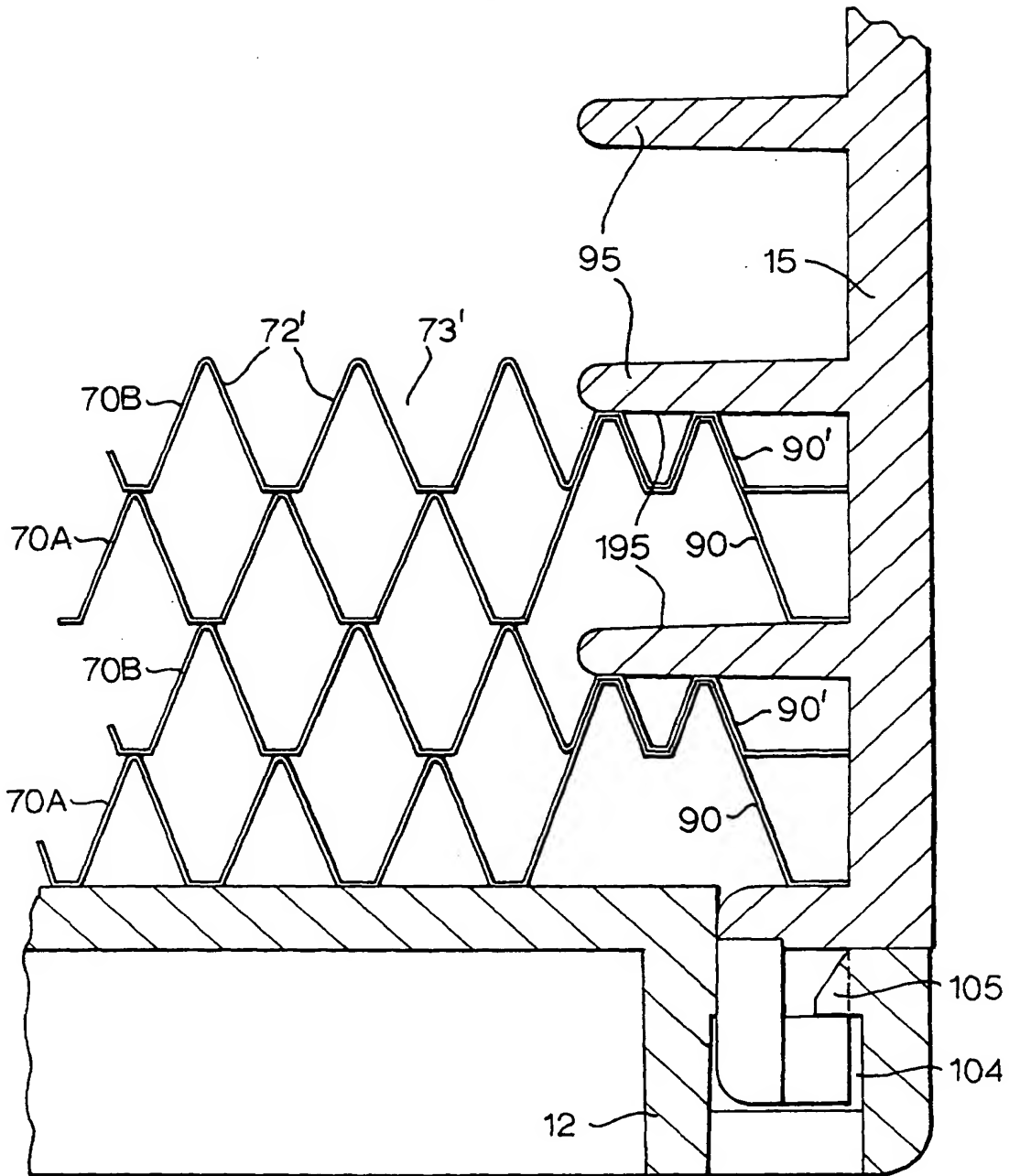
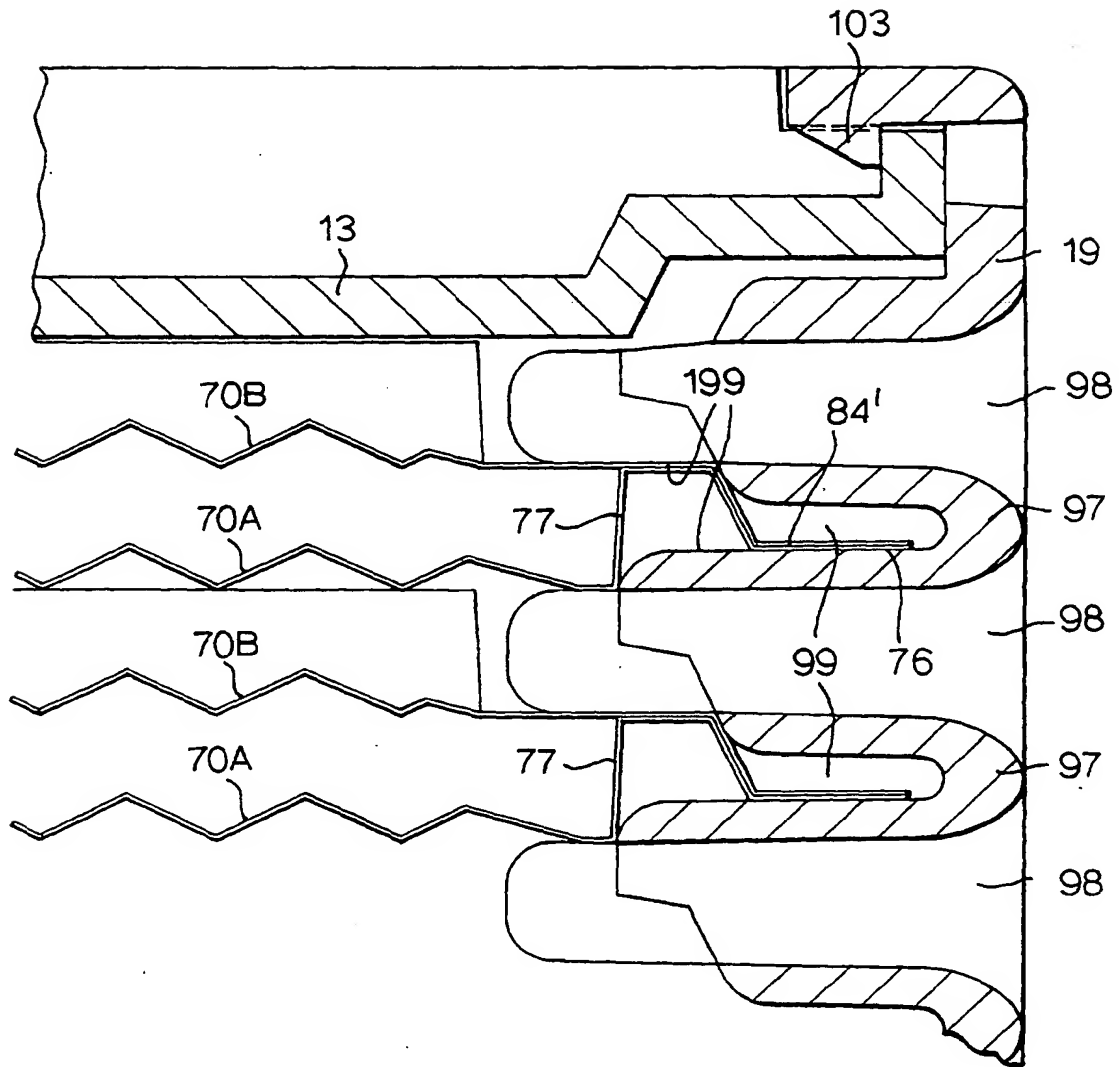
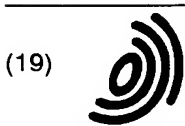


Fig.12.





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(11) EP 1 191 297 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:  
24.07.2002 Bulletin 2002/30

(51) Int Cl.7: F28D 9/00

(43) Date of publication A2:  
27.03.2002 Bulletin 2002/13

(21) Application number: 01307730.0

(22) Date of filing: 11.09.2001

(84) Designated Contracting States:  
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE TR  
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AL LT LV MK RO SI

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(30) Priority: 23.09.2000 GB 0023427

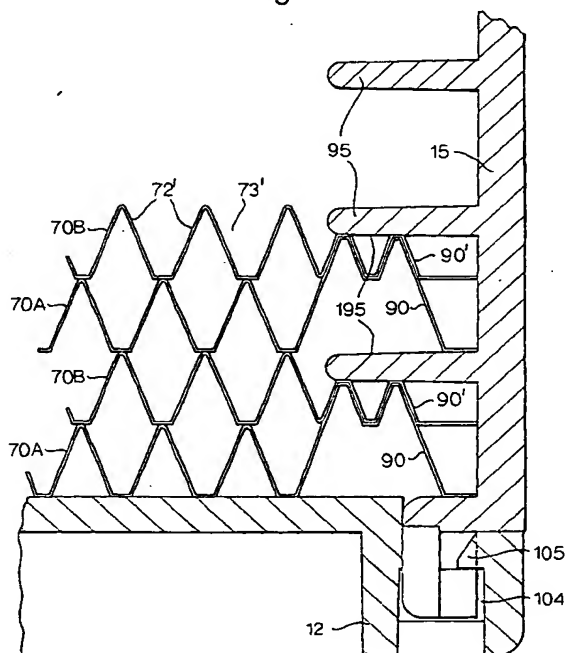
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Fig.11.



EP 1 191 297 A3



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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
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EPO FORM 1503 03/92 (P4C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
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EP 01 30 7730

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